Contribution ID: **4** Type: **not specified**

Optical quantum metrology, a story of modes

Wednesday, 18 September 2024 08:30 (2 hours)

Quantum optical metrology aims at identifying the ultimate sensitivity bounds for the estimation of parameters encoded into an optical field, positioned at the intersection of quantum physics, signal processing, and electromagnetism. By leveraging the concepts of quantum and classical Fisher information, it is possible to both benchmark optical apparatus and propose strategies to optimize optical measurements. In this lecture, we will introduce the concepts of (Quantum) Fisher information and Cramér Rao bound, but also of practical estimators such as the method of moments. We will do so having in mind practical applications, such as imaging, and remote sensing, where the parameter of interest is encoded not only in the quantum state of the field but also in its spatio-temporal distribution, i.e., in its modal structure. We will illustrate this with the example of estimating the separation between two incoherent sources, and its extension to efficient multi-parameter estimation.

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